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The Extension Pathologist

"TO PROMOTE ECONOMIC CROP PRODUCTION,
IMPROVE THE QUALITY OF PLANT PRODUCTS, AND
REDUCE WASTAGE IN STORAGE, TRANSIT, AND AT THE MARKET"

CONTROL OF VEGETABLE DISEASES IN STORAGE

FIELD MEETING OF THE AMERICAN PHYTOPATHOLOGICAL SOCIETY

THE EXTENSION PATHOLOGIST

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FACTORS AFFECTING THE CONTROL OF VEGETABLE DISEASES IN STORAGE *

By J. I. Lauritzen, Associate Pathologist, Office of Vegetable and Forage Diseases, Bureau of Plant Industry, United States Department of Agriculture.

Resistance and Susceptibility to Diseases

The most effective method of controlling any disease is to obtain a plant resistant or immune to it. Two strains of the Yellow Jersey variety of sweet potato, one susceptible and the other resistant to surface rot, have been discovered. Quantities of each strain were subjected to sixteen combinations of curing and storage conditions during the season of 1925-26. (1). The average percentage of infection obtained at the end of the storage season of the susceptible was 43 while that of the resistant strain was 7.

Although such instances of resistance may be found in the case of other diseases of sweet potato and other vegetables, this method of control is of limited application as is indicated by the history of efforts made to the control of plant disease. As long as vegetables remain susceptible to diseases other methods of control must be employed.

Origin of Diseases

The control of vegetable diseases is conditioned somewhat on whether the disease has its origin in the field or in the storage house. Such diseases as late blight of potato and black rot of sweet potato are primarily field diseases, but at times occasion considerable loss in storage. The losses caused by them can be greatly reduced or eliminated by employing the field control measures available. If diseased stock is placed in storage, one must grapple with these diseases there, and often with secondary diseases that follow in consequence of the necrotic condition produced.

Vegetables that are free from field diseases or the organisms that produce them, when they are stored, generally will remain so during storage. In their absence, the diseases that develop in storage are caused by microorganisms which are more or less omnipresent. The control of these diseases depends on such factors as the weather during the growing, harvesting and storing the crop, wounding, and the conditions in the storage house, such as temperature, humidity, etc.

* Paper presented at the Fifth International Congress of Refrigeration April 9-15, 1928, at Rome, Italy. Also presented in part at the Extension Session, Annual Meeting of the American Phytopathological Society, Nashville, Tennessee, December 28, 1927.

Weather.

The weather, particularly solar radiation, temperature, and moisture, prevailing during the growing and especially during the harvesting and the storing of the crop, is thought to have an important relation to the keeping of vegetables in storage. Our knowledge regarding the part these various elements of weather play is limited, but there are cases where definite connections are known to exist. Onions harvested during rainy weather are very susceptible to decay. Dry weather, on the other hand, favors their keeping.

The Maturity of the Crop.

The maturity of the crop is often a determining factor in the keeping of vegetables in storage. Mature onions are much more resistant to neck rot than immature ones.

Curing.

Curing is the term applied to the treatment to which certain vegetables are subjected, preliminary to or in connection with the beginning of storage. In case of onions it may consist of exposing them to warm sunshine and dry air in the field until the bulbs, particularly the necks, are thoroughly dry, or subjecting them to artificial heat and plenty of air. (7). Sweet potatoes are cured by exposing them to temperature varying from 75° F. to 85° F., with good ventilation in a storage house for a period of ten days to two weeks.

Walker has shown (7) that losses caused by neck rot of onions can be greatly reduced by artificial curing, if the bulbs are stored under favorable conditions. There are no published data on the relation of curing to specific diseases of sweet potato, but it is believed that their keeping qualities are improved by this preliminary treatment.

Wounding.

Wounding is a determin ing factor in the initiation of some diseases, aggravates the amount of decay caused by other diseases, and seems to play no part in the development of still

others.

Rhizopus rarely ever infects sweet potatoes, except through fresh wounds. By the careful handling of this crop, in and out of storage, and by avoiding wounding by rodents, it is possible to nearly eliminate this disease.

The decay of carrots known as black rot is increased by wounding, although infection is not dependent upon it. (3)

Wounding seems to play little or no part in the decay of carrots by Rhizopus.

The Effect of Prestorage and Shipment of Vegetables.

Vegetables are often stored after they have been shipped to the market. They may have been shipped direct from the field or after they have been in storage for some time. In such storage the vegetables have been subjected to more handling and in turn more wounding, and in consequence, are often more susceptible to disease than vegetables stored direct from the field. They, also have been exposed, in the one instance to the conditions prevailing in the railroad car, and in the other to those obtaining in the railroad car and in the storage house. These conditions are often favorable to the development of disease. As a result, the vegetables are often in the process of decay when they are stored at the markets. Carrots badly infected with watery soft rot and slimy soft rot are often placed in storage with the idea of holding them for a better market.

Although some diseases may be held in check by proper storage, others will continue to develop no matter what the conditions of storage are. Black rot of sweet potatoes (3) will continue to develop even below temperatures at which infection will occur. There probably are other diseases that will develop under conditions that prevent infection.

The Presence of Absence of Pathogenic Organisms in The Storage House.

The presence or absence of pathogenic fungi and bacteria in the storage house governs in many instances the diseases that prevail and is subject to partial control. Aside from what can be done to eliminate and control the diseases that have their origin in the field, it is possible to govern in part the fungi and bacteria that will be present in storage. First, by disinfecting the storage house, it is possible to eliminate the microorganisms, wholly of field origin, that have been introduced by the previous storage of the vegetable or vegetables involved, and possibly reduce the quantity of the strictly storage organisms that will prevail during the storage season; second,

it is possible to govern in part the pathogenes that will prevail by controlling such conditions as temperature, moisture, etc. This fact will become clear in the discussion below.

Air Movement and Air Exchange

Air movement and ventilation (air exchange) are probably factors of considerable importance in connection with the storage of vegetables, but their relation to specific diseases has not been worked out; consequently, they will only be mentioned here.

Atmospheric Humidity

Atmospheric humidity is thought to be a factor of some importance in connection with the control of the storage diseases of vegetables, although very little is known about it. In general it has been thought that a high humidity favors infection, which probably is often, if not generally, true. One cannot be certain, however, of its relation to a particular disease until one has isolated and studied its effects directly.

Indeed a surprising relation is found in case of infection of sweet potatoes by Rhizopus (5). Instead of a high humidity favoring infection, it acts as a barrier at relative humidities between 90 and 100 per cent., and at a temperature of 73° F. As the humidity is lowered the percentage of infection increases until a maximum is reached at relative humidities between 75 and 84 per cent. As the humidity is lowered still further the percentage of infection becomes considerably less.

The explanation of this strange relation seems to be found in the effect of humidity on the host rather than on the pathogene, because if sweet potatoes that have been subjected to humidities of 89 to 97 per cent, (temperature 73° F.) for a period of from four to twelve days are then placed at humidities from 48 to 89 per cent., very few become infected. On the other hand, a high percentage of roots become infected if they have first been exposed to humidities of 51 to 73 for a period of from four to twelve days and are then placed at humidities of 84 to 95 per cent. These facts show that the pathogenes (*Rhizopus tritici* Sarto and *R. nigricans* Ehrenb.) are able to infect at high humidities in the absence of the host resistance that develops at the higher humidities. This resistance is located in the wounded surfaces, because when these surfaces are removed and the potatoes are placed at favorable humidities they readily become infected.

Temperature.

Temperature, without doubt, is the most important single factor in the control of storage diseases of vegetables. It has been employed more extensively than any other and more is known about it. By employing

the proper temperatures, diseases are eliminated in some instances; in others, the losses are greatly reduced; and, in still others, temperature merely determines the particular disease or diseases that will prevail.

Diseases That Can be Eliminated by Controlling of Temperature.

We are accustomed to think of low temperatures as the ones effective in the elimination of disease in storage, and while this is generally true, it is not always so. Mucor racemosus Fes. causes decay of sweet potatoes only at temperatures between 32° and 48° F., although it will grow over a far wider range of temperature in culture media. Its optimum for infection is about 41° F., and for growth in culture about 77° F. Its ravages are so great between 32° and 48° F. that if it were necessary to store potatoes at these temperatures we could not hold them successfully beyond a few weeks, because over most of this temperature range, 100 per cent. of the roots become infected at the humidities that usually prevail in the storage house. By raising the temperature above 48° F., the disease produced by this organism can be eliminated altogether.

A striking case of control of a disease by the manipulation of temperatures is that of soil rot (Rhizoctonia solani) of turnips. This pathogene scarcely produces any decay throughout the storage season at temperatures between 32° F. and 37° F., while at temperatures of 46° to 50° F. it affects practically all the roots after four months of storage. Fortunately, turnips have few and unimportant troubles at temperatures between 32° and 41° F., so that they can be stored with scarcely any loss.

It is not known how extensively soil rot of turnips is distributed. It has occurred in turnips grown and stored at Washington during the past three seasons, and to practically the same extent each year. It has also been observed on New York markets in both turnips and rutabagas.

Rhizopus tritici and R. nigricans both cause some decay of carrots in storage, but the decay produced by them, probably, can be eliminated by storing the roots at temperatures below 45° F. Very little decay occurs below 68° F. R. nigricans, which is the species that causes practically all the decay in sweet potatoes at temperatures below 68° F. (4), is rarely ever isolated from carrot. At temperatures above 77° F., R. tritici is very active and causes heavy losses. Temperature seems to be the controlling factor in the disease produced by these organisms.

Slimy soft rot is one of the most important storage diseases of carrots. Carrots that are free from this disease when they are placed in storage can be kept so, if they are held at temperatures between 32° and 37° F. Carrots stored from the field are usually free from slimy soft rot. It is only when they are subjected to high temperatures in the field or in previous storage or shipment that there is any danger of this disease developing at the temperatures given above.

Slimy soft rot is a disease common to most vegetables. It is believed that it can be eliminated in the case of most uninfected vegetables if they are held at temperatures below 41° F.

The Reduction of Losses by Governing the Temperature in the Storage House.

The rate of development of most plant diseases is largely a function of temperature. As a rule, it is accelerated as the temperature rises from a minimum for infection to an optimum temperature for development. As the temperature rises above the optimum the rate declines until a temperature is reached at which the disease ceases to advance. It is often impossible to store vegetables beyond the temperature limits of infection. In such cases all that can be done is to place them at temperatures, usually low temperatures, at which the advance of the disease is as near a minimum as possible. This procedure is practical when the normal rate of development of the disease is slow. Watery soft rot and black rot of carrots establish themselves at as low a temperature as 32° F. (6) (2), but the rate of development is so slow that it is possible to hold the roots for fairly long periods at temperatures from 32° to 35.5° F., without much advance of decay.

Temperatures Functioning in Governing the Disease that Predominates.

When carrots, free from disease are stored directly from the field the strictly storage diseases that hold sway are largely governed by the temperature that prevails. There is a succession of diseases as the temperature rises from 32° to 104° F. At temperatures between 32° and 41° F., Botrytis rot predominates. Fortunately, the losses caused by this disease are small. The decay is largely confined to the fine tip end, and in most instances, does not reach the thickened portion of the root, although a large percentage of the carrots are infected after four months of storage. As a rule not over five per cent. are decayed sufficiently by March to affect their market value.

A number of organisms, including _Botrytis_ sp., _Fusarium_ sp., _Rhizopus nigricans_, _Penicillium_ sp., and _Bacillus carotovorus_ decay carrots at temperatures between 41° and 68° F. The decay at these temperatures is not large but the tops become infected. In consequence, the roots become messy, making them undesirable for the market.

Although _Bacillus carotovorus_ causes some decay at temperatures between 41° and 64° F., it is very slight. It is the predominating pathogene, causing heavy losses at temperatures between 64° and 77° F. _Rhizopus tritici_ makes rapid inroads at temperatures above 77° F. _Pencillium_ sp., is the active agent as 104° is approached, largely, it is believed, because the roots are injured by such temperatures.

More might be said on the control of diseases of vegetables in storage by temperature, but the foregoing will illustrate some of the problems involved. Much more work needs to be done before our knowledge will be complete.

It will be seen that the problems of the control of vegetable diseases in storage are complex. First, because the factors entering into the problem are involved, reacting on each other and on the host and parasite. Second, because the factors affecting disease vary with the host and parasite. Even when the same parasite infects and decays different hosts, it sometimes does so under different conditions and hence involves different factors; and third, because each vegetable is affected by a number of diseases. Notwithstanding this complexity, success has attended the storage of vegetables and we are making progress in the solution of the remaining problems.

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FIELD MEETING OF THE AMERICAN PHYTOPATHOLOGICAL SOCIETY

August 20 - 21 - 22, 1928.

The Advisory Board of the American Phytopathological Society voted to hold a summer meeting on the diseases of ornamental plants. This meeting will be held in the vicinity of New York City on August 20, 21, and 22. This date has been selected so that those in attendance at the International Meeting of Entomologists at Cornell August 12 to 18 will be able to join the summer tour.

The following program is tentative but will not be changed greatly in its final form. The tour has been so arranged as to reduce the number of stops and distances traveled to a minimum to allow ample time for observation and discussion. All trips will be made by bus or train so as to keep the group together. A New York hotel, to be indicated in the final announcement, will be selected as the headquarters.

(Time indicated is Eastern Standard Time)

August 20. Leave hotel headquarters in New York by bus at 8:30 A.M. (9:30 A.M. Daylight Saving Time.). Visit F. & F. Nursery at Springfield, N. J. After lunch visit the Bobbink and Atkins and Julius Roehrs Nurseries at Rutherford. These three nurseries, among the largest in the Eastern states, specialize in the growing of all types of evergreens, annuals, perennials, and shrubs.

August 21. Arrive at Greystone via Hudson River Division of the New York Central at 8:28. Inspect the Boyce Thompson Institute. A number of experiments on Aster Yellows, Lily Mosaic, etc., in progress at the Institute will be of interest. After lunch, visit the adjoining estates of Colonel Thompson and Mr. Samuel Untermeyer.

At 3:00 P.M. leave for the New York Botanical Garden, Bronx Park, where Dr. B. O. Dodge will explain his problems in the pathology of ornamental plants.

Leave for hotel headquarters at 5:30 either by the Harlem Division of the New York Central to Grand Central station, or by subway to Times Square.

August 22. Leave hotel headquarters by bus at 8:00 A.M. Stop at Central Park, Bronx Parkway, and several estates on way to Stanford, Connecticut. An opportunity will be afforded to study the effects of fertilizers, results from spraying, and improper pruning,

prevention of wind damage, cavity treatments and general tree service in promoting health in trees under varying conditions. Lunch at Bartlett Research Laboratory. During the afternoon experiments and demonstrations on cavity treatments, wound dressings, internal therapy, spraying and fertilization will be examined. Leave for New York about 4:00 P.M.

W. H. Rankin
L. O. Kunkle
C. R. Orton
L. M. Massey
W. H. Martin

Committee on Summer Tour,

American Phytopathological Society.

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THEATRE TICKETS REWARD BOYS AND GIRLS WHO PLANT WHITE PINE

Mr. John B. Eames who owns and operates eight large movie and vaudeville theatres in northern New Hampshire has worked up a novel scheme to interest school children in planting white pine.

Mr. Eames proposes to give a theatre ticket to each and every school boy or girl who will plant one or more white pines during Arbor week in their respective towns. He will likewise supply the trees for distribution.

It will be my duty to visit all the schools previous to Arbor week and instruct the teachers regarding method of planting, protection, etc., as they will in turn supervise the work of the school children during planting time. A Pathe News cameraman will be in Littleton, N. H., at the time to take pictures of the event, as we propose to give it wide publicity.

If the scheme works out as we anticipate and the children show an interest in this sort of thing, we will give them something to do on blister rust work before school closes in June. The proposition will be outlined in the press so that the venture will be news for everyone and we feel that a great deal of good will come from it.

Thos. L. Kane - New Hampshire

(From the Blister Rust News.)

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WITH THE STATES

Colorado

While approximately 85% of Colorado wheat growers are using copper carbonate treatment for winter wheat, the Extension Service feels that a further check-up on results secured should be carried this summer and plans are being made accordingly. Last year's results showed pure copper carbonate to control smut within 1% where formaldehyde and blue vitriol showed approximately 2% smut.

Many druggists are stocking the organic mercury dusts for seed corn treatment but are not being supported by this service. Demonstrations are being carried to prove the value or lack of value of this treatment. An interesting angle is that many growers are using this dust to keep pheasants from eating seed after planting.

Waldo Kidder.

Kansas

The Seventh Annual Kaw Valley Potato Tour will be held June 13, 14 and 15. The result demonstrations, conducted by the County Farm Bureaus, cooperating with the Extension Service at the Kansas State Agricultural College, will be visited. A basket dinner will be given each noon by the women of the local Farm Bureaus.

Visitors are expected from nine nearby states and from several market centers. Anyone interested in a detailed schedule write to C. E. Graves, Extension Plant Pathologist, K.S.A.C., Manhattan, Kansas.

C. E. Graves.

Maryland

Microscopic studies of the development of the apple scab fungus were made on last year's fallen leaves. As a result of these studies fruit growers were advised to spray their trees in the pre-pink stage. In the extreme southeastern part of the State, fruit growers who used oil sprays in the dormant or delayed dormant stages were advised to spray again with lime sulphur, since mature ascospores were found while the trees were dormant.

Demonstrations on the control of cucumber mosaic were planned on ten farms in Wicomico County. Good results were obtained last year by destroying wild hosts in the vicinity of the fields, roguing and controlling insect carriers, and these methods will be tried again this year.

R. A. Jehle

Virginia

A considerable amount of work is being done this month in dusting tomato plant beds with the copper-lime-arsenate dust. The tomato growers themselves are very interested in this work and are following our recommendations in whole communities.

S. B. Fenne.

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Articles, news notes, or suggestions with regard to subjects that might profitably be discussed in this news sheet, should be addressed to:

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Extension Plant Pathologist,
Bureau of Plant Industry,
U. S. Department of Agriculture,
Washington, D. C.